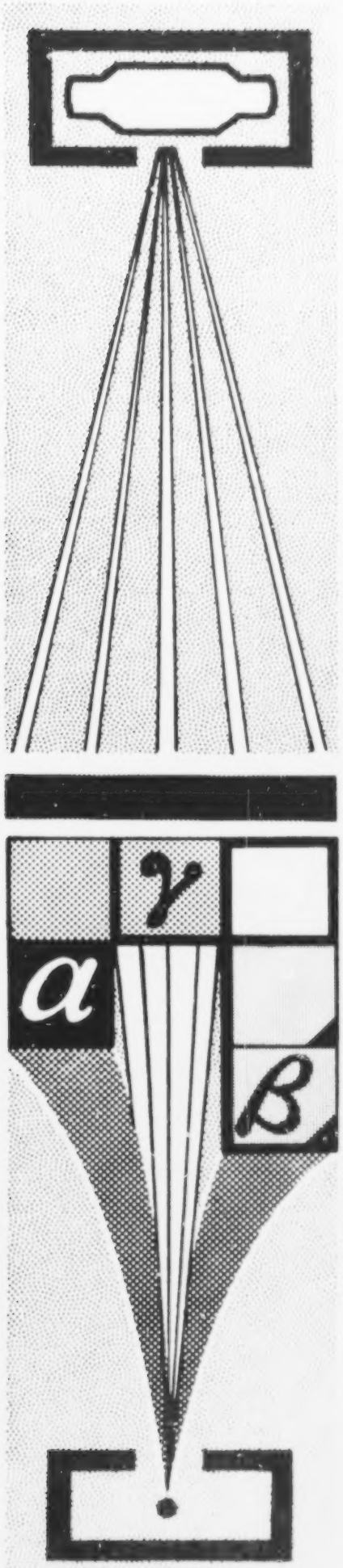

PB 184356

DENTAL SURPAK SUMMARY REPORT

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18

TECHNICAL REPORTS

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PHS 1582	Radiation Protection Survey Report Manual
PHS 1663	KWIC Index to the Journal of the Health Physics Society (1958-1966) (PB 176 092)
PHS 1831	KWIC Index to the Journal of Nuclear Medicine (1960-1967) (PB 179 074)
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MORP 68-8	Dental X-ray Teaching and Training Replica
MORP 68-9	Development and Evaluation of an Automatic Collimator for Medical Diagnostic X-ray Machines (PB 180 528)
MORP 68-10	Survey of the Use of Radionuclides in Medicine: Preliminary Report
MORP 68-11	Dental Surpak Summary Report
MORP 68-12	Particle Accelerator Safety Manual (PB 178 325)
MORP 68-13	PHS Film Badge Program (In preparation)
MORP 68-14	Radiation Safety Recommendations for X-ray Diffraction and Spectrographic Equipment (PB 182 558)

MORP 68-11

DENTAL SURPAK
SUMMARY REPORT

prepared by

Radiation Machines and Applications Branch
Division of Medical Radiation Exposure

APRIL 1968
Revised March 1969

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Consumer Protection and Environmental Health Service
Environmental Control Administration
Bureau of Radiological Health
Rockville, Maryland 20852

FOREWORD

The Bureau of Radiological Health, formerly the National Center for Radiological Health, continues to carry out a national program designed to reduce the exposure of man to hazardous ionizing and non-ionizing radiation.

Within the Bureau, the Division of Medical Radiation Exposure deals with 1) the reduction of unproductive ionizing radiation exposure of patients, workers, and others exposed by the use of X-rays and other machine produced ionizing radiation, radioactive materials and radiopharmaceuticals, and 2) the improvement of radiological "systems" and methodology in the healing arts.

The Bureau publishes its findings in Radiological Health Data and Reports (a monthly publication), the Environmental Health Series, Public Health Service numbered reports, appropriate scientific journals, and Division technical reports.

The technical reports of the Division of Medical Radiation Exposure (DMRE), formerly the Medical and Occupational Radiation Program (MORP), allow comprehensive and rapid publishing of the results of intramural and contractor projects. The reports are distributed to State and local radiological health program personnel, Bureau technical staff, Bureau advisory committee members, university radiation safety officers, libraries and information services, industry, hospitals, laboratories, schools, the press, and other interested individuals. These reports are also included in the collections of the Library of Congress and the Clearinghouse for Federal Scientific and Technical Information.

I encourage the readers of these reports to inform the Bureau of any omissions or errors. Your additional comments or requests for further information are also solicited.

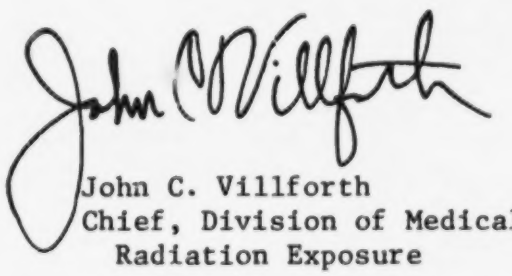
Raymond T. Moore

Raymond T. Moore, M.D.
Acting Bureau Director

PREFACE

Since 1960 when the first dental Surpaks were introduced by the Bureau of Radiological Health, more than 52,000 of these mail-order survey packets have been provided to participating health agencies for distribution to dentists throughout the country. During this period the Surpak provided an effective and economical means of identifying potential sources of unnecessary radiation exposure from dental X-ray machines and, thus, proved to be a most valuable public health tool.

The information contained in this report represents the collective efforts of numerous individuals and organizations. We wish to specifically acknowledge the efforts of the various Federal, State, and local health agencies which participated in the Dental Surpak Program. Personnel of the Data Systems and Mathematics Section, Bureau of Radiological Health, assisted in compiling the results.



John C. Villforth
Chief, Division of Medical
Radiation Exposure

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BACKGROUND

Soon after the formation of a Division of Radiological Health[1] within the Public Health Service, it was determined that evaluation of possible unnecessary radiation from dental X-ray machines was a project of prime importance. Initial investigations indicated the need for a rapid method for evaluating dental X-ray units throughout the United States; however, because of the large number of dental X-ray machines in the country (approximately 95,000) (1) and the limited radiological health manpower at the State and local levels, an on-site physical inspection of each machine was not possible. Therefore, an alternative survey technique was developed. In this technique a film packet, designated the dental Surpak, was mailed to the dentist, exposed by him with his X-ray unit, and mailed back to the health agency. The Surpak was then processed and analyzed in conjunction with the dentist's answers to questions printed on the film pack envelope to provide information about various machine parameters, including beam size and symmetry, total filtration, approximate Roentgen output in milliroentgens per milliampere-second, and leakage radiation in the direction of the patient's face. The design and use of the dental Surpak are described in the article, "The Dental Surpak Survey Method." (2)

FIELD TRIALS

Following in-house development and testing of the Surpak in August 1959, a pilot study was conducted in cooperation with the Prince Georges County, Maryland, Health Department to test the practicality and reliability of the Surpak. The dental facilities of the National Institutes of Health were used to instruct County personnel in the use of the Surpak. In this study the surveyors exposed the Surpaks and also performed on-site physical surveys of the facilities to permit comparison of results. Preliminary results of the Prince Georges County study indicated that the Surpak was suitable for use in a survey conducted by mail. Therefore, a field trial was initiated in North Dakota in January 1960, through arrangements with the State Department of Health, under the actual conditions that could be anticipated in a nationwide program. Approximately 80% of the dentists in the State voluntarily participated in the survey; however, 13% of the processed Surpaks were not readable. Analysis of the readable Surpaks revealed that 76% had primary beam diameters greater than 2.75 inches. This is the maximum beam diameter currently recommended by the American Academy of Oral Roentgenology. (The NBS Handbook 76 recommendation is 3.00 inches.) Sixty-six percent had less filtration than the recommended 2.0 mm aluminum equivalent. Follow-up physical surveys were conducted on selected X-ray units for comparison studies.

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[1]Now the Bureau of Radiological Health

Evaluation of the results of the pilot study and the field trial indicated that the dental Surpak was a suitable tool for evaluating specific parameters of large numbers of dental X-ray machines in a relatively short time. Thus, in the fall of 1960 the Division of Radiological Health began providing Surpaks to State and local health agencies for mailing to individual practitioners. The dentists then mailed the exposed Surpaks to the health agencies for forwarding to the Division's Rockville, Maryland, Laboratory for processing and interpretation (see figures 1 and 2). Results obtained from the processed films were recorded on data punch cards and later transferred to magnetic tapes. Finally, printouts of the tapes were sent to the State and local health agencies.

Distribution and processing of Surpaks continued at a rapid pace until 1963; by December 30 of that year, 40,663 Surpaks had been processed by the Division. The Surpak program continued at a decreasing rate through 1967, with some of the Surpaks exposed being used in follow-up surveys to ascertain whether machines previously surveyed and found to be defective had been brought into compliance with recommended standards.

RESULTS

The following tables present a summary of the results of the Dental Surpak Program from 1960 to 1966. The tables were produced from information stored on magnetic tape and present results from 52,367 Surpaks. Forty-one States and one territory participated in the Dental Surpak Program: Alabama, Alaska, Arizona, Arkansas, California, Colorado, Connecticut, Georgia, Hawaii, Indiana, Iowa, Kansas, Kentucky, Maine, Maryland, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, New Jersey, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin, Wyoming, and Puerto Rico.

Distribution of Dental Surpaks

Table 1 shows the distribution of dental Surpaks by calendar year. No figures are shown beyond 1966, the year in which phase-out of the Surpak program began. However, Surpaks had already reached over 50% of the estimated number of dental X-ray machines in the United States through 1966. However, even in the years of smaller samples (1964-1966), there was a continuation of the trends evidenced earlier in the program (1960-1963) with regard to beam size, filtration, and beam symmetry, that is, the results show a continuous improvement.

Table 1. Distribution of dental Surpaks. (1960-1966)

	Distribution of Dental Surpaks							
	1960	1961	1962	1963	1964	1965	1966	Total
Number	1,130	11,525	16,846	11,162	5,063	3,875	2,766	52,367
Percent	2.1	22.0	32.2	21.3	9.7	7.4	5.3	100.0

Although the primary purpose of the Surpak was to provide the States with a rapid method for evaluating the initial status of their dental X-ray equipment, some duplication exists in the yearly totals because of resurveys made using the Surpak. Since no provision was made on the Surpak form for coding of resurveys, it is not possible to determine the extent of duplication.

Beam Diameter

Beam diameters produced by dental X-ray machines were determined by direct measurement of the exposed (blackened) portion of the developed Surpak film. Table 2 shows that the percentage of dental X-ray machines with beam diameters of three inches or less increased from approximately 41% in 1960 to approximately 83% in 1966. In 1966 approximately 63% of the beams had diameters of 2.75 inches or less; however, more than 17% of the beams exceeded 3 inches.

Table 2. Percentage distribution of beam diameters of dental X-ray machines as determined from dental Surpaks. (1960-1966)

Beam Diameter	Percentage of Dental Surpaks						
	1960	1961	1962	1963	1964	1965	1966
Less than 2.76	32.5	44.2	49.3	48.1	57.2	61.1	62.5
2.76-3.00	8.7	13.9	14.3	19.1	22.8	18.6	20.2
3.01-4.00	53.4	36.6	31.4	27.9	16.8	17.1	14.8
4.01 or greater	5.4	5.3	4.9	4.9	3.1	3.2	2.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Figure 1. Determination of beam size, beam symmetry, and leakage radiation from processed Surpak film.

Filtration

Filtration determinations were based on densitometer readings made at several points on each processed Surpak film. Table 3 presents a changing picture of filtration adequacy in dental X-ray machines through seven years. The criteria used to establish adequacy of filtration are those stated in NBS Handbook 76, paragraph 10.1.d. In 1960, 59.5% of dental X-ray machines appeared to be inadequately filtered, but by 1966, 80.4% were adequately filtered. The abrupt shift in 1964 in the percentage of machines of 70 kVp or more is probably due to the trend toward the use of higher kVp in both dental X-ray machines and techniques. At the same time, the shift in the percentage of these that met filtration requirements is possibly due to the adoption by States of their own regulations resulting in a natural impetus to compliance efforts. It should be noted that whereas the proportion of machines less than 70 kVp to machines of 70 kVp or greater with adequate filtration was approximately 4 to 1 in 1960, it was approximately 1 to 1 in 1966.

In those dental X-ray machines with kVp less than 70, the proportion of those with adequate filtration to those with inadequate filtration was about 1 to 1 in 1960, and approximately 5 to 1 in 1966.

Table 3. Percentage distribution of dental X-ray machines by adequacy of filtration, kVp considered, as determined from dental Surpaks. (1960-1966)

Adequacy of filtration kVp considered		Percentage of Dental Surpaks						
kVp	Filtration	1960	1961	1962	1963	1964	1965	1966
Less than 70	adequate	32.9	41.9	49.7	46.8	48.8	40.9	39.2
	inadequate	33.7	29.1	21.8	24.0	7.7	11.0	7.6
70 or greater	adequate	7.6	4.5	6.2	6.6	23.4	33.9	41.3
	inadequate	25.8	24.6	22.3	22.6	20.1	14.2	12.0
Total	adequate	40.5	46.3	55.9	53.4	72.2	74.8	80.4
	inadequate	59.5	53.7	44.1	46.6	27.8	25.2	19.6

Type of Cone

The type of cone in use was indicated by the dentist on the Surpak envelope. Table 4 shows that closed pointed cones were in use most often. (Information regarding cone type was not requested until 1964.)

Table 4. Percentage distribution of dental X-ray cones by type as determined from dental Surpaks. (1960-1966)

Type of Cone	Percentage of Dental Surpaks						
	1960	1961	1962	1963	1964	1965	1966
Closed Pointed	No Information				92.3	92.5	95.0
Open Cylinder					6.7	7.5	5.0
Total					100.0	100.0	100.0

Length of Cone

This information was also indicated by the dentist on the Surpak envelope. In Table 4A it can be seen that aiming devices which result in a tube target-to-tip-of-cone distance of eight inches or less are used most often. (Older X-ray units using mechanical timers can be modified for use with high speed film by the addition of a long cone and quadruple exposure time.)

Table 4A. Percentage distribution of dental X-ray cones by length as determined from dental Surpaks. (1960-1966)

Distance from Target-to-Tip-of-Cone (Inches)	Percentage of Dental Surpaks						
	1960	1961	1962	1963	1964	1965	1966
Generally 8 or less	92.2	91.8	92.7	88.2	85.4	90.8	92.0
Approximately 15	7.8	8.2	7.3	11.8	14.6	9.2	8.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Roentgen Output at Tip of Dental X-ray Cone in Milliroentgens Per Milliampere-Second (1960-1964)

The Roentgen output of dental X-ray machines described in Table 5 is expressed as milliroentgens per milliampere-second. This was calculated using the milliamperage specified in the machine manufacturer's literature. This method did not allow for changes to machines made by the owner in milliamperage settings nor for the fact that a choice in milliamperage was possible by changing the setting on the console. To allow for the choices or adjustments in milliamperage settings the calculation of the Roentgen output was made on the basis of the milliamperage used as reported by the dentist and the unit of measurements was changed to Roentgens per second. The range of output for dental X-ray machines as presented in Tables 5 and 5A are comparable if the milliamperage can be presumed to be 10 in both cases. However, if the milliamperage is 15, then it might be presumed that there has been a considerable shift to lower Roentgen output.

Table 5. Percentage distribution of Roentgen output at tip of dental X-ray cone as determined from dental Surpaks. (1960-1964)

Roentgen Output at Tip of Cone (mR/mAs)	Percentage of Dental Surpaks					
	1960	1961	1962	1963	1964	Total
Less than 51	11.3	8.6	7.8	11.5	15.0	9.5
51-100	32.3	22.2	27.9	31.7	29.8	27.7
101-150	27.8	31.4	33.3	32.3	33.1	32.3
151-200	15.6	21.9	18.6	16.5	14.8	18.6
201-999	13.0	15.9	12.4	8.0	7.3	11.9
Total	100.0	100.0	100.0	100.0	100.0	100.0

Table 5A. Percentage distribution of Roentgen output at tip of dental X-ray cone as determined from dental Surpaks. (1964-1966)

Roentgen Output at Tip of Cone (R/sec.)	Percentage of Dental Surpaks			
	1964	1965	1966	1964-1966
Less than 0.51	20.0	16.1	12.9	16.4
0.51-1.00	39.4	33.2	30.4	34.3
1.01-1.50	21.8	21.7	22.9	22.1
1.51-2.00	10.5	13.0	10.9	11.6
2.01-9.99	8.3	16.0	22.9	15.6
Total	100.0	100.0	100.0	100.0

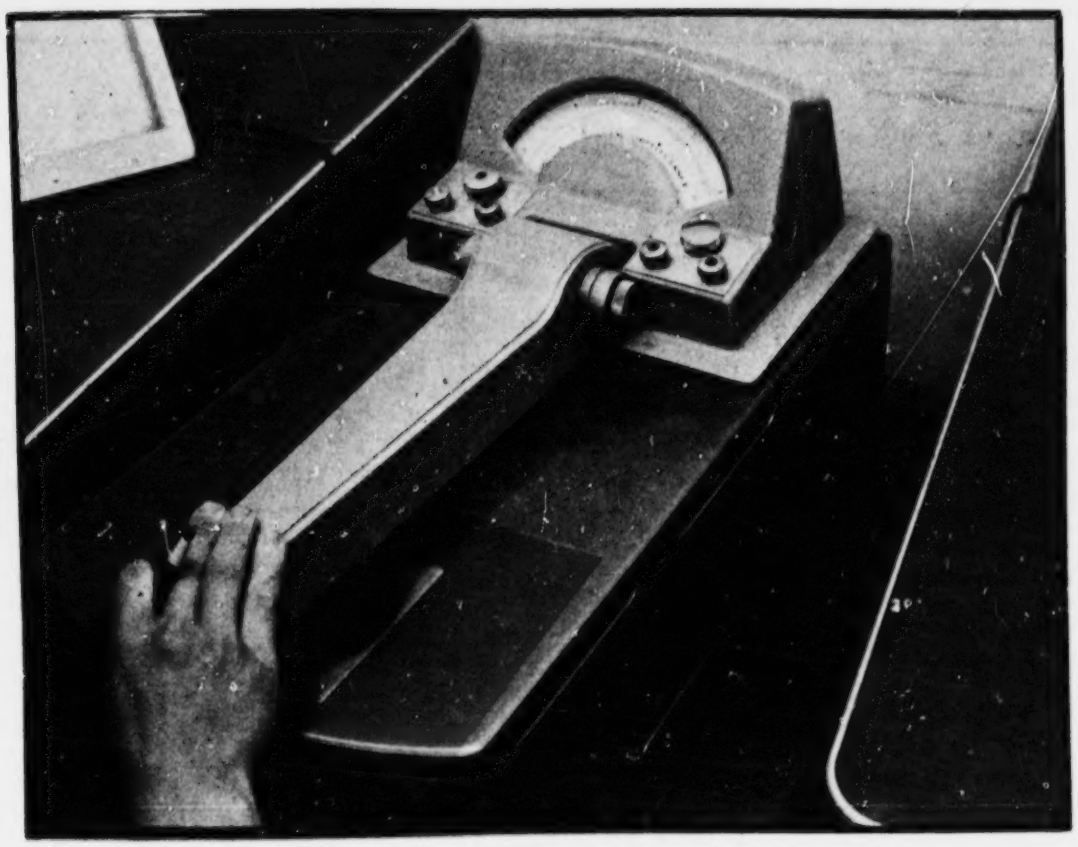

Figure 2. Densitometer readings taken on processed Surpak film to determine Roentgen output and filtration.

Primary Beam Leakage from X-ray Tube Housing

In analyzing the Surpaks, primary beam leakage is defined as primary radiation discernable on the 8- by 10-inch film that is not limited to the area of the useful beam at the tip of the cone.

Table 6 indicates that as determinable by the dental Surpak, primary beam leakage in a forward direction from the tube housing is not a significant problem.

Table 6. Percentage distribution of dental X-ray machines with primary leakage as determined from dental Surpaks. (1960-1966)

Primary Leakage (>100 mR/hr.)	Percentage of Dental Surpaks						
	1960	1961	1962	1963	1964	1965	1966
Yes	1.9	2.9	2.5	4.5	5.0	2.8	2.3
No	98.1	97.1	97.5	95.5	95.0	97.2	97.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Beam Symmetry

By 1966, the shape of the dental X-ray beam, as determined by direct observation of the processed Surpak films, was judged to be "good" in almost 99% of the observations. In the first year of available data beam symmetry was classified as poor in 8.2% of the observations.

Table 7. Percentage distribution of dental X-ray machines by beam symmetry as determined from dental Surpaks. (1960-1966)

Beam Symmetry	Percentage of Dental Surpaks						
	1960	1961	1962	1963	1964	1965	1966
Good	91.8	97.3	97.6	97.5	98.3	98.9	98.7
Poor	8.2	2.7	2.4	2.5	1.7	1.1	1.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Conclusions

At a time when radiation protection programs in many States were in the early stages of development and were hampered by inadequately trained personnel, the dental Surpak proved to be a practical substitute for the physical survey of dental X-ray machines. It provided a means for States to quickly ascertain major defects in the radiation safety status of dental X-ray machines within their jurisdiction.

While most of the Surpaks were exposed and interpreted accurately, difficulties were encountered due to a number of variables which could not be readily controlled. One problem of the Surpak was the error introduced when a dentist failed to expose the envelope according to directions; e.g., placing the aiming device at an angle other than 90^{o}, misinterpreting exposure-time instructions, or not having the pointer cone in contact with the Surpak envelope. Readout procedures were not always capable of detecting such discrepancies, and thus errors were introduced in such cases. Additional errors resulted from incorrect responses by the dentists to the questions on the Surpak envelope, indicating ambiguity in the questions or a lack of familiarity with the types of information requested.

CITED REFERENCES

(1) GLASS, R. L. Mortality of New England Dentists 1921-1960. PHS Publication No. 999-RH-18 (May 1966).

(2) MILLER, J. W. Summary of state dental radiological health activities. Radiol Health Data Rep 4:41-45 (January 1963).

ADDITIONAL REFERENCES

(1) MILLER, J. W. Progress in dental radiological health. Radiol Health Data Rep 5:499-504 (October 1964).

(2) MILLER, J. W. The dental surpak program and results through December 1963. Radiol Health Data Rep 6:271-277 (May 1965).